Optical Fiber Sensor Instrumentation for Slagging Coal Gasifiers

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OBJECTIVE

The objective of this program is to develop an optical fiber sensing system to monitor refractory thickness and temperature in a slagging coal gasifier for improved reliability and advanced process control in the coal fired power plants of today as well as the FutureGen power generation systems of the future. A silica-based fiber sensor head, suitable for operation up to 800-900º will be utilized for monitoring the refractory wall thickness and a sapphire-based fiber sensor head will provide temperature data from inside the gasifier, building directly on several key technologies developed at Virginia Tech, including a novel white light interferometry data processing algorithm, silica-to-sapphire fiber connectorization, and sapphire-to-sapphire material bonding.

ACCOMPLISHMENTS TO DATE

The corrosion rate of the refractory wall is measured by optical time domain reflectometry (OTDR) using an embedded length of optical fiber. Temperature monitoring is achieved using an extrinsic Fabry-Perot interferometer (EFPI) formed by a sapphire fiber and wafer. During the first several months of this program, accomplishments include signal processing algorithm development for the sapphire temperature sensor, thickness sensor design and development of fabrication procedures, development of the data acquisition and analysis software for the wall thickness sensor, design of laboratory experiments for thickness measurement, room temperature testing, sensor package design, and testing at 600°C.

Work on the sapphire temperature sensor has focused on design and modification of the sensor electronics. To accommodate the longer distances that will be found in an actual coal gasifier plant, the communication capability of the serial interface was extended. All the optical and electrical components were installed into a standalone box. A signal-processing program was written to retrieve the optical spectrum from the optical measurement instrument and to determine the temperature readings from calibration curves. The historic temperature reading data as well as the raw optical spectra are recorded.

A new fabrication method was developed to achieve similar reflectivity from the two reflection points in the thickness sensor by introducing a discontinuity in the sensing fiber at the reference point. The thickness measurement graphical user interface (GUI) allows the user to control the wall thickness data acquisition process, switch between different data processing methods and record

original data from the OTDR and the computation results from the software. Several parameters such as sample interval, average time and average type can be adjusted. The software has a high efficiency algorithm for peak searching and distance measurement. During testing, it was found that the reflection signal amplitude from the sensing point of the fiber has a large fluctuation range. The software algorithm was therefore designed to have the ability to recognize peaks and determine whether they are distorted due to saturation. It also can adjust the sensitivity of OTDR automatically during the peak searching and position estimation procedures such that the peaks with lower amplitude will not be missed and the peaks with higher amplitude will not be distorted.

High temperature test will be conducted in two steps. Data collected at 600ºC will be used to evaluate the sensor package and data processing algorithm prior to testing at 1000ºC test, which will be much closer to field test conditions. Sensors have been packaged and experiments at 600°C have begun.

FUTURE WORK

For the next several months, the work will focus high temperature testing of the prototype system. Experiments at 600°C will continue. The sensor package and signal processing algorithm will be thoroughly evaluated and modified accordingly prior to the start of 1000°C experiments

LIST OF PAPERS PUBLISHED, U.S. PATENT/PATENT APPLICATION(S), CONFERENCE PRESENTATIONS, AWARDS RECEIVED AS A RESULT OF SUPPORTED RESEARCH, STUDENTS SUPPORTED UNDER THIS GRANT

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